

# Detection and diagnosis of iatrogenic inadvertent diversion of partial inferior vena cava into the left atrium by transesophageal echocardiography during large posteroinferior surgical atrial septal defect closure

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**Abstract** Iatrogenic diversion of the inferior vena cava (IVC) into the left atrium (LA) is usually reported as a rare complication following large posteroinferior atrial septal defect (ASD) surgery. It may cause acute or chronic hypoxemia, and other potentially life-threatening complications such as stroke. We present a case in which the ASD patch straddled the IVC entrance diagnosed immediately by transesophageal echocardiography (TEE) during the period of patient separated from cardiopulmonary bypass, avoiding the related complications. Our report further underlines the important role of TEE to monitor and guide ASD surgical management, especially secundum ASD with inferior extension or inferior sinus venosus defects, for the early diagnosis of iatrogenic surgical errors.

**Keywords** TEE · Atrial septal defects · Inferior vena cava · Left atrium · Surgical ASD closure

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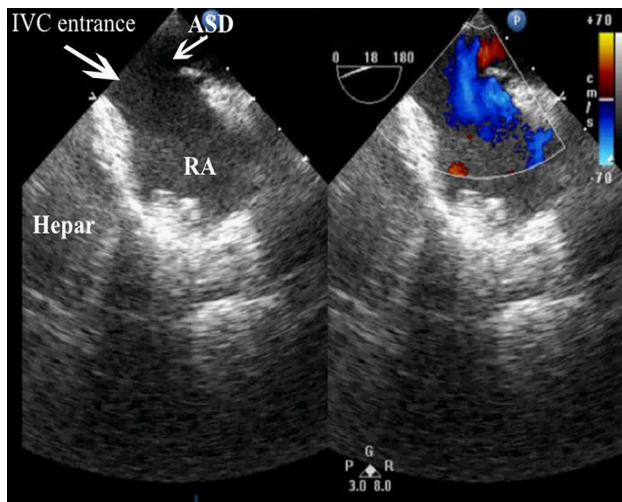
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## Introduction

Iatrogenic diversion of the inferior vena cava (IVC) into the left atrium (LA) is usually reported as a rare complication following surgical large posteroinferior atrial septal defect (ASD) closure [1]. Urgently, it may cause hypoxemia. Chronically, it may cause cyanosis and clubbing of fingers [2]. Even as pulmonary hypertension and other potentially life-threatening complications like stroke due to paradoxical embolism. Most common situations that account for the inadvertent diversion are large Eustachian valves that were mistaken for the margin of the ASD [1]. Now we present another situation of inadvertent diversion in a case with large septum secundum ASD. The point of this diversion is not caused by Eustachian but the prominence of IVC. Our report further underlines the important role of transesophageal echocardiography (TEE) in monitoring and guiding ASD surgical management, especially secundum ASD with inferior extension or inferior sinus venosus defects, for the early diagnosis of iatrogenic surgical errors.

## Case report

We present the case of a 34-year-old woman with a history of an exertional dyspnea and a systolic murmur noted on examination at the III–IVth intercostal space along the right sternal border, which on further examination with transthoracic echocardiography (TTE) was identified as a large septum secundum ASD (approximately 4.0 × 5.0 cm) lying low in the atrium near the orifice of IVC, with atrium-level left-to-right shunt. The TTE also demonstrated a dilated right atrium, a partial anomalous pulmonary venous connection (right upper pulmonary vein



**Fig. 1** TEE confirmed the preoperative diagnosis. The secundum atrial septal defects had inferior extension. The white arrow on the left indicates the IVC entrance and the white arrow on the right indicates the secundum ASD. IVC inferior vena cava, ASD atrial septal defect

draining to the right atrium (RA), a moderate tricuspid valve regurgitation, and pulmonary hypertension (pulmonary arterial systolic pressure was 48 mmHg). She was referred to surgery for closure of the ASD, repair of tricuspid valves, and treatment of the partial anomalous pulmonary venous connection. Written informed consent was obtained from the patient and her husband prior to this publication.

In the operating room, anesthesia was induced uneventfully. In addition to other monitors, a transducer of TEE was placed and the preoperative diagnosis was confirmed (Fig. 1). She achieved total cardiopulmonary bypass (CPB) by a median thoracotomy approach, with aortobivaval cannulation. The ASD was identified and sutured, closed with rerouting the right upper pulmonary vein to the LA, and tricuspid valve plasty was performed. The right atriotomy was then closed. During the termination of CPB, unexpectedly the pulse oxygen saturation was about 92 % and continued to deteriorate. At this stage, there was no residual shunt and tricuspid valve regurgitation by TEE detection, and the arterial blood gases showed that oxygen saturation was 90.2 %. A midesophageal bicaval view at multiplane 75° angle revealed an abnormal blood flow from the IVC entrance draining to left atrium (LA) (Video Clip 1). We focused on the interatrial septum (IAS) and reconfirmed that there was no residual shunt. Then, the TEE probe was focused on the IVC flow and tracked from the -IVC-right atrium junction. We found that parts of the IVC flow were seen draining to right atrium (Video Clip 2), and the other part of the IVC flow draining to the LA (Video Clip 3). We began to doubt that the patch straddled the IVC entrance. After repeated tracking of IVC flow, we

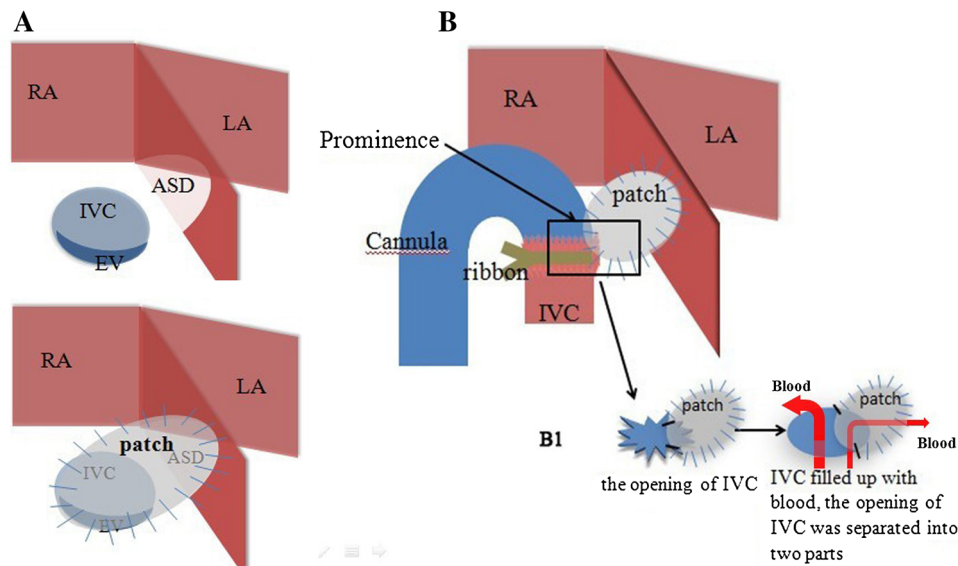
affirmed this idea. TEE redefined the right upper pulmonary vein draining into the LA.

So the blood originating from the IVC was confirmed to split into two branches. A direct partial IVC to LA communication was created, which was equivalent to a right-to-left shunt. Incomplete diversion of the IVC into the left atrium by the suture was inferred. Meanwhile, the newest arterial blood gases showed that oxygen saturation was 76 %. Surgeons then decided to re-explore the ASD repair under endoaortic occlusion and cardioplegic arrest. To explore the rim of the entrance of the IVC clearly, cannula in right femoral vein replaced that in IVC and CPB was reinstated. After right atriotomy, the patch was found to be sutured to the salient rim of the IVC entrance. The suture line was then taken down and the ASD was defined and repaired. No abnormal flow was then detected. The patient had an uneventful postoperative course.

## Discussion

Inadvertent diversion of the IVC into the left atrium (LA) is usually reported as a rare complication following surgical large posteroinferior ASD closure in the era of CPB [1]. In many reported cases, this complication was detected years after operation because of cyanosis or clubbed fingers [3, 4]. Jain et al. [5] and Desai et al. [1] described the inadvertent diversion of IVC into the LA since presentation of stroke 2 or 30 years after operation, while Bjork et al. [6] and Thompson et al. [2] present patients in whom hypoxemia occurred immediately after surgery on the operating table or in the open-heart recovery room, diagnosed by cardiac catheterization or contrast echocardiogram. Most situations accounting for the inadvertent diversion are large Eustachian valves, which are mistaken for the margin of the ASD [2–6] (Fig. 2a). In the presence of a large Eustachian valve, the surgeon may be even more inclined to close the gap from the valve toward the upper septal margin rather than the posterior ASD itself. In addition to large Eustachian valves mistaken for the margin of the ASD, there is another form of inadvertent diversion. For example, the lower portion of the defect was too low to be closed [4] by direct suture or by means of a patch, thus creating a direct IVC-to-LA communication failure to recognize an IVC type of sinus venosus ASD [1]. Secundum ASD with inferior extension is often confused with inferior sinus venosus defects [7].

Nevertheless, the secundum ASD patient in our report is another situation with a similarly created right-to-left shunt discovered immediately during her separation from CPB. With the help of TEE, the iatrogenic accident was detected in time and related complications were avoided. When surgeons re-explored the ASD repair, they found that the



**Fig. 2** **a** Large Eustachian valve mistaken for the lower margin of the ASD. **b** The anterior and posterior of the left rim of the IVC entrance flocked together and were salient to be a prominence. The left-most rim closed to the septal was pinned by the ribbon. The prominence closed to the septum was mistaken for the lower margin of the ASD.

**B1** after removal of the cannula and the ribbon, the IVC entrance filled up with blood, and the opening of the IVC was separated into two parts. The ASD patch straddled the IVC entrance. *ASD* atrial septal defect, *IVC* inferior vena cava, *LA* left atrium, *RA* right atrium, *EV* Eustachian valve

ASD patch had straddled the IVC entrance (Fig. 2b). Posteroinferior defect was so large and the ribbon fixed the cannula in IVC was so tight that the anterior and posterior of the left rim of the IVC entrance flocked together and were salient to be a prominence. The left-most rim closed to the septum was pinned by the ribbon. The prominence closed to the septum was mistaken for the lower margin of the ASD (Fig. 2b). The surgeons closed the defect from the prominence toward the upper septal margin. Then, after removal of the cannula and the ribbon, the IVC entrance filled up with blood and the opening of the IVC was separated into two parts. A direct partial IVC-to-LA communication was created. Ross and Johnson [8] described that a distortion of the IVC orifice by a snare may lead to inaccurate placement of sutures and failure to appreciate the relationships of the lower edge of the atrial septum. If the surgeons placed the occlusion tape on IVC as far away as possible from the right atrium or the IVC be cannulated peripherally via the femoral vein, it might have been easier to distinguish the IVC entrance and the lower margin of the ASD [6, 8].

In addition to surgeons of more careful, few measures exist to avoid such surgical errors during surgical ASD closure [1]. Non-invasive modalities like magnetic resonance and contrast CT scan are usually used to accurately diagnose this complication years after operation before the patient is taken up for a reoperation [5]. However, they are not suitable for an intraoperative setting. Cardiac catheterization and contrast echocardiogram can easily be

applied intraoperatively. Especially contrast echocardiogram, which performed with agitated saline injected into the lower extremity, is a rapid, non-invasive, and reliable way of diagnosing such lesions [2]. After surgical closure of secundum ASD with inferior extension or inferior sinus venosus defects under CPB, TEE should focus on the draining of IVC and the detection of residual shunt in midesophageal (ME) biatrial view and four-chamber view. If an abnormal flow appears, we should track it from the standard view and find the origin, course, and drainage site of the flow, judgment it synthetically combined with Doppler. If it was considered as a remnant shunt flow, then the IAS should be focused on. If it was considered an IVC flow, one needs to display the liver from the ME bicaval view, then from the hepatic vein (HV) and IVC junction to tracking the IVC on both 2D and spectral Doppler, until the IVC-RA junction appears. However, it is worth noting, when tracking the IVC from the origin (the HV-IVC junction), that sometimes you will only find that it drains into the RA while actually part of the flow may drain into the LA. So, tracking the flow in the reverse direction (from the drainage site to origin) is necessary. Meanwhile, IVC flow draining into the LA needs to be distinguished from normal upper-right pulmonary vein.

Our report further underlines the important role of TEE in monitoring and guiding surgical management of ASD, especially secundum ASD with inferior extension or inferior sinus venosus defects, for avoid iatrogenic surgical errors.

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**Conflict of interest** There are no conflicts of interest to declare.

## References

1. Desai M, Talwar S, Kothari SS, Jagia P, Airan B. Inferior vena cava to left atrium shunt presenting with polycythemia and stroke three decades following closure of atrial septal defect. *Congenit Heart Dis.* 2013;8:102–5.
2. Thompson E, Moritz D, Perdue R, Cansino S. Diversion of the inferior vena cava following repair of atrial septal defect causing hypoxemia. *Echocardiography.* 2004;21:329–32.
3. Unger P, Bondue A, Loiseau J, Dessy H, Primo G, Le Clerc JL. Right-to-left shunting with normal pulmonary pressure complicating atrial septal defect surgery. *Int J Cardiol.* 2006;113:252–3.
4. Beitzke D, Koestenberger M, Knez I, Beitzke A. Anomalous connection of the inferior vena cava to the left atrium: a surgical error in closing an atrial septal defect. *Clin Res Cardiol.* 2008;97:191–3.
5. Jain SA, Pinto R, Dalvi B. Iatrogenic diversion of IVC to left atrium after surgical closure of ASD. *Ann Pediatr Cardiol.* 2012;5:72–4.
6. Bjork VO, Johansson L, Jonsson B, Norlander O, Nordenstrom B. The operation and management of a case after diversion of the inferior vena cava into the left atrium after the open repair of an atrial septal defect. *Thorax.* 1958;13:261–6.
7. Plymale J, Kolinski K, Frommelt P, Bartz P, Tweddell J, Earing MG. Inferior sinus venosus defects: anatomic features and echocardiographic correlates. *Pediatr Cardiol.* 2013;34:322–6.
8. Ross JK, Johnson DC. Complications following closure of atrial septal defects of the inferior vena caval type. *Thorax.* 1972;27:754–8.